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UNITED STATES MARINE CORPS
PROVISIONING MEASURES OF EFFECTIVENESS

by

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United States Marine Corps
Provisioning Measures of Effectiveness

by

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ABSTRACT

This thesis investigates measures of effectiveness (MOE) and defines the data elements for an automated USMC repair parts initial provisioning evaluation system. Twenty-three specific MOEs, applicable to any new weapon system, are proposed from five general criteria categories: weapon system readiness, supply support, cost, essentiality and range/depth. Then, each MOE is examined for practical implementation potential by identifying and/or modifying data elements resident in USMC automated files. To assist in the database programming of MOEs, Appendices B through E define and cross-reference the MOEs, automated files and data elements.

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I. THE NEED FOR PROVISIONING CRITERIA

A. INTRODUCTION

During the 1980's the United States Marine Corps witnessed the most profuse equipment modernization program in its history. The Commandant of the Marine Corps reported to Congress in January 1986, "We plan to replace every single weapon system within the Marine Division--from the pistol to the main battle tank--in a decade." [1:27]. Much management and journalistic attention has been focused upon the acquisition cost, while less has been paid to the cost of repair parts to support these new weapon systems. Yet support is also quite expensive. Over the next six years the Marine Corps projects an average of $32 million will be spent for repair parts to support the fielding of new weapon systems [2].

Provisioning, in simple terms, is the selection and procurement of repair parts to support newly fielded equipment. This is no easy chore, however, because the provisioner confronts a fundamental dilemma; namely, predict and buy all parts that a weapon system will need in its first years, but buy no more than needed. If he buys too few, readiness suffers and Marines lose confidence in the weapon and its support system. If he buys too many, investment dollars are wasted, high holding costs result, and other opportunities for getting a military return on dollars spent must be foregone.

Many factors confound the provisioning effort. Engineering configurations may change, maintenance concepts may be ill-defined, equipment/part reliability estimates may err drastically, budgets may change, vendors vary in capabilities to support secondary requirements, unit deployment schedules may change and so on All of these unknowns often change over the provisioner's decision-making horizon.

B. OBJECTIVES

The main objective of this thesis is to uncover and develop useful criteria to measure USMC provisioning effectiveness after-the-fact and, on a practical bent, derive data element definitions to assist in the Marine Corps Logistic Base, Albany, GA. (MCLBA) Weapons Systems Automated Information System (WS/AIS) development effort.

An abundance of provisioning literature published in recent years has focused either upon forecasting models or has decried the poor results of forecasting models in a lessons learned format. This paper will take a different approach and describe, define and measure the effectiveness of provisioning. This distinction is important. While DOD and USMC directives set forth the grand goals of provisioning, specific measures of effectiveness (MOEs) are not stated.

Therefore two central research questions will be addressed:

1. What are some useful MOEs that the Marine Corps can apply to its provisioning process?
2. What data elements are relevant to these MOEs?

It is hoped this thesis will prompt open discussion of MOEs by the many stakeholders in the provisioning process: provisioners, weapon systems managers, inventory managers, contractors, acquisition project officers, budgeteers, field maintenance personnel, supply personnel and, perhaps most importantly, the Marines who will use this equipment on the battlefield.

C. SCOPE

This paper considers only the initial provisioning of repair parts for newly fielded USMC Fleet Marine Force (FMF) ground equipment. Aviation items and pre-positioned war reserve stocks (PWR)[1] are excluded. Technical publication, tool, test equipment and training provisioning is also excluded. Only repair parts issues are addressed.

D. ASSUMPTIONS

This thesis assumes a beneficial role for explicit MOEs. As Casey Stengel, former manager of baseball's New York Yankees, once stated, "If you don't know where you're going you may end up somewhere else." MOEs can tell you where you are going.

As a result of recent USMC provisioning efforts, new policy has evolved which has led to the publication of a revised provisioning manual [3]. The intention of this thesis is to provide a needed connection between the broad goals and policies of provisioning and specific measures to evaluate provisioning effectiveness.

E. RESEARCH METHODOLOGY

Information was acquired by an exhaustive review of periodicals held by the Naval Postgraduate School; review of DOD, USMC and other service documents, reports, staff studies and research papers from the Defense Logistics Studies Information Exchange; review of pertinent DOD, DON and USMC directives and staff reports; and dozens of interviews with MCLBA logistics managers.

For an in-depth review of provisioning issues refer to two studies. Provisioning Responsibilities, Procedures and Requirements Determination in the United States Marine Corps, a 1979 thesis by Captain Paul M. Lee, USMC, topically outlines the intricate world of Marine Corps provisioning [4]. Marine Corps Provisioning Policy

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[1] PWR is USMC equipment held in storage pending outbreak of war.

Review Staff Study Report Of 1980 explains past problems encountered with MOEs and data extraction [5].

F. ORGANIZATION OF STUDY

This thesis contains five chapters and five appendices. Chapter I has discussed the purpose, scope and assumptions. Also presented were the methods of research and the organization.

In Chapter II DOD and USMC provisioning objectives and responsibilities are cited. Discussion of provisioning processes and tasks acquaint the reader with the basic work flow. Past USMC efforts at provisioning measurement are synopsized and the current automated systems development at MCLBA is presented.

Proposed measures of effectiveness are analyzed in Chapter III. Five general categories are scrutinized for MOE alternatives. Particular emphasis is placed upon conceptual pitfalls likely to be encountered in using each MOE.

Chapter IV defines specific data elements, relationships and the computational aspects for each MOE of Chapter III. One objective is to demonstrate the feasibility of tracking desired MOEs with an automated information system.

Chapter V concludes with a summary of the issues raised and recommendations for further research.

Appendix A is a list of acronyms. Appendix B defines each data element while Appendix C describes the subfiles needed to isolate the data elements of interest. Appendix D shows a cross-reference of MOEs, sub-files and data elements. In Appendix E an MOE/Data Element matrix is offered.

II. SURVEY OF USMC PROVISIONING

A. DOD POLICY

Department of Defense Directive 4140.40 establishes the objectives and policies of initial provisioning in support of new weapon systems. The main objective of provisioning is to:

> assure the timely availability of minimum initial stocks of support items at using organizations and at maintenance and supply activities to sustain programmed operation of end items until normal replenishment can be effected, and to provide this support at the least initial investment cost. [6:2]

This instruction further charges DOD components (i.e., the USMC) with the responsibility for final determination of the range and quantity of support items required for the initial outfitting of new end items entering the operating inventory.

Department of Defense Instruction 4140.42 sets forth specific procedures and mathematical models to determine the initial requirements for secondary item repair parts. The goal is to provide the minimum number of parts needed to achieve a satisfactory level of weapon system performance until the more reliable actual demand history becomes available and normal replenishment procedures can be accomplished. [7:2] At the wholesale level, the COSDIF model computes the range of parts to be stocked as demand-based by comparing the expected cost of holding the item to the expected cost of not stocking the item over the first two years of supply support of a weapon system [7:Encl.3]. The depth of demand-based items includes expected demand during procurement lead time plus a procurement cycle/safety level quantity [7:Encl.2].

Two instances occur in which nondemand-based items, those that fail the COSDIF test, may be stocked at the wholesale level: insurance items and numeric stockage objective (NSO) items. An insurance item is an essential item for which no failure is predicted through normal usage, but the lack thereof would significantly degrade weapon system readiness. An NSO item is an essential item for which failure may be predicted, but does not meet the demand based stockage criteria. Lack of an NSO item would also seriously impair weapon system readiness. A quantity of one minimum replacement unit of each insurance or NSO item may be stocked. Retail stocks are determined by USMC models and will be discussed briefly in section D of this chapter.

B. USMC POLICY

The Marine Corps Provisioning Manual of 31 January 1986 promulgates the basic instructions, procedures and guidance of all functions and operations relating to provisioning in the USMC. It states:

> Initial provisioning must include the identification, selection, and acquisition of items required for maintenance, and provide instructions to ensure that necessary initial support items are positioned in the supply system and maintenance echelons before new equipment is placed in service. [3:1-3]

This statement is useful for our purposes insofar as it emphasizes provisioning's contribution to the maintenance effort and stresses the importance of supply procedures. Since these actions must occur before equipment is placed in service, the decision-making horizon is very uncertain.

C. USMC RESPONSIBILITIES

1. Headquarters Marine Corps

The Commandant of the Marine Corps (CMC) is responsible for the acquisition, funding, and procurement of new weapon systems. The CMC sets provisioning policy and monitors its execution. To do this, the HQMC staff coordinates cross-service procurement agreements, disseminates provisioning budget documentation, and includes requirements for ordering repair parts and provisioning technical documentation (PTD). Essentially, HQMC provides policy goals and budget guidance to MCLBA provisioners.

2. Marine Corps Logistics Base, Albany

MCLBA is the nucleus of USMC provisioning and has a plethora of management and technical responsibilities. Rather than list all, only those pertinent to this work are cited:

* Develop initial provisioning budget documentation;
* Develop plans to ensure orderly transition from contractor to USMC supply support;
* Devise procedures and schedules to transmit supply support requests to Defense Logistics Agency, General Services Administration, or other services Weapons Systems Integrated Materiel Managers; and
* Review interservice support agreements annually to ensure they meet USMC provisioning requirements.

A final responsibility, central to this thesis, is best presented directly from the source:

> Establish a provisioning effectiveness evaluation system that ensures the IIP support sustains equipment readiness at minimum cost and minimum contribution to excesses at the end of the demand development period. This system should use the weapon system code and identification number to identify usage against a specific application. [3:1-12]

Thus, MCLBA not only manages the provisioning program but is also charged with the creation of the program evaluation system. Therefore, the MCLBA has considerable leeway in the design of the evaluation system.

3. Fleet Marine Force

As users of new weapons systems Fleet Marine Force (FMF) units are the customers that the provisioning program must satisfy. If the repair parts that eventually are demanded are not initially available then FMF units must take requisitioning action, and suffer degraded readiness status while awaiting the parts. Therefore, the full impact of HQMC and MCLBA policy, budgeting, and decision-making is most acutely felt at this level.

4. Summary

There are many intricacies of Marine Corps provisioning but the essence is as follows: HQMC sets policy and budget parameters and FMF units must operate within the constraints of initially provisioned repair parts. MCLBA enjoys the central role of doing the provisioning; that is, deciding what parts will be initially procured and evaluating the effectiveness of those decisions. Simply stated, the goal is to maintain high equipment readiness at the least cost.

D. PROVISIONING PROCESSES

Provisioning planning commences at MCLBA upon receipt of the Five Year Defense Plan which shows the expected phase-in and phase-out of weapon systems. CMC issues funding requirements which serve as a top-line dollar figure or an upper bound for planning purposes.

The Procurement, Marine Corps Planning Execution Shopping List sets forth the initial provisioning financial plan. Funds are listed by weapon system and are based on historical data of similar systems, technical experience and parametric cost estimates. As more specific information becomes available HQMC publishes a Letter of Adoption and Procurement which states end item replacement factors, life expectancy, phase in/out schedules and maintenance factors. HQMC communicates other key information to MCLBA in the Field Budget Guidance and Provisioning Guidance Data. These documents detail the breakdown of weapon systems by unit, echelon of maintenance responsibilities and a fielding timetable. Selected program data from the above documents is then entered in subsystem-10 (SS-10) of the Marine Corps Unified Materiel Management System (MUMMS) [8].

HQMC and MCLBA jointly determine the provisioning technical documentation required of the contractor when the Marine Corps procures a weapon system. If another service or agency procures the weapon system for the Marine Corps, then HQMC submits a list of the PTD desired. Provisioning technical documentation consists of replacement factors, unit prices, repair times, recycle times and other assorted data derived through logistics support analysis [9]. MIL-STD-1388-2A provides a complete list of data elements [10].

The Marine Corps takes an active role regardless of the service which procures the weapon system. PTD is combined in MUMMS SS-10 with aforementioned operational and budget program data and is passed through assorted mathematical models. The resulting computer output reports furnish the provisioner with an initial recommendation of how many parts to buy.

The provisioner has the final responsibility for identification, computation and selection of initial repair parts. Parts essential to the operational readiness of combat essential equipment are closely scrutinized. The contractor may assign source, maintenance and recoverability codes[2], combat essentiality codes, replacement factors and repair rates during preparation of the PTD. Even so, provisioners use the Marine Corps Level of Repair Analysis program [11], knowledge of USMC support structures and technical judgment to review, evaluate and adjust PTD. Technical records are then researched to identify the appropriate WIMM for each part because consumables that are already in the DOD supply system are not allowed to be stocked by the Marine Corps. In this case, the USMC will send supply support requests to the appropriate supply source to make sure

[2] SMR codes communicate the manner of acquiring items; the maintenance levels authorized to remove, replace, repair, assemble, manufacture and dispose of items; and the reclamation or disposition action required.

enough parts are in the supply system prior to the planned material support date.

The calculation of the range and depth of repair parts must incorporate risk factors. The Marine Corps uses mathematical models derived from DODI 4140.42 to initially determine specific wholesale quantities needed to support a weapon system for a two year demand development period [7]. Models for retail quantities are contained in reference [3]. For an in-depth discussion of these models and proposals for new models the reader should see the 1987 study by Love and Stebbins [12].

Initial provisioning inventories can be classified into three general categories: pre-positioned war reserve, initial system stock and initial allowance quantity. PWR contains materiel for both the active and inactive mobilization forces. Since this is used only in war time, it is not considered here. System stock are consumables held at the wholesale level and consist of a safety level quantity and a procurement cycle lead time quantity. The initial system stock provides backup support for the entire density of weapon systems until routine replenishment can be established (normally two years). Stock levels vary depending upon the criticality of the end item, the PCLT, the replacement rate and the demand forecasting method used. Initial screening through MUMMS SS-10 determines whether parts can be stocked as demand-based at the wholesale level.

The initial allowance quantity, also called the garrison operating level (GOL), are the initially procured repair parts positioned at the FMF level. GOL is usually held by a Force Service Support Group Supply Battalion. FMF personnel normally refer to this stock as IIP, a short-hand term for an initial issue support package managed and monitored by the supply battalion's SASSY Management Unit. GOL consumable depth is based on estimated replacement factors and an order and ship time (OST). Neither safety stock nor items already in the supply system are authorized. GOL reparable depth is based on expected operational requirements, maintenance capabilities, OSTs, replacement rates, repair rates, repair cycle times and washout rates. Computations for the GOL and the IIP time horizon is described in Chapter IV of reference [3]. The GOL, which constitutes the IIP for FMF units, is of primary interest in this paper.

Even though mathematical models help determine the range and depth of system stock and IIPs, provisioning remains more art than science. The process is sensitive to the estimates and predictions made using program data and PTD as inputs. Therefore, the intervention of technical value judgments by provisioners is needed. In fact, a recent study documented that 69% of initial parts requirements were derived from the provisioner's technical judgment, not from pure reliance on the output of mathematical models [13].

Given these complexities and uncertainties, by what criteria should initial provisioning be evaluated? Past Marine Corps efforts to answer this question will be discussed next.

E. USMC EFFECTIVENESS STUDIES

During 1980, eight military and civilian experts conducted a major provisioning program review. Taking nearly a year to compile, the final report showed evidence of excess provisioning of repair parts. One conclusion stated that a high degree of equipment readiness (94%) could be maintained despite a substantial reduction (35%) in initial inventory. [5:5]

The "Brown Report", named after its senior member, arrived at these conclusions after developing 13 measures of effectiveness and searching various automated maintenance and supply files for data to compare against stated criteria. Initial MOEs included operational readiness, shortage and overage costs, criticality measures and range and depth measures. Upon discovery that the required data either did not exist or could not be extracted the original 13 MOEs were reduced to 9 MOEs. Two significant data problems were encountered.

First, there was a problem with data integrity, much of the maintenance and supply data was considered inaccurate or incomplete. Second, even though many of the data elements existed, the files and programs were not designed to extract the data in the format needed for the analysis. Hence, costly computer programmer hours were devoted to reconfiguring and recomputing the data. Annex I of the Brown Report documents these problems in more detail [5]. The databases were designed to support FMF operational needs, rather than provisioning evaluation studies. One salient recommendation of the Brown report was to develop a provisioning effectiveness evaluation system [5:5].

During the 1980s, most MCLBA computer programming efforts were devoted to the design, development and implementation of the Marine Corps Standard Supply System. M3S added a database management system to maintenance and supply automated information systems files. Though not programmed to automatically output provisioning effectiveness measures, M3S does make data easier to view and extract.

An April 1985 USMC provisioning conference again resurrected the issue of an evaluation system [14]. HQMC tasked MCLBA to report the effectiveness of only a few new weapon systems. To include all new weapon systems would have been too costly, time consuming and cumbersome.

At the time of this writing, provisioning effectiveness evaluation studies include only a few weapon systems and are done within the constraints of a database system ill-designed for the task. No software program exists to automatically compute MOEs and problems persist regarding the configuration of the database to support this endeavor [15]. So provisioning may be evaluated as Lee noted in 1979:

> ...(by) the frequency of complaints from operational, maintenance and supply personnel...This negative feedback approach places enormous pressure on the provisioner to ensure that more than enough parts are on hand to short circuit the complaints. Without an objective method of evaluation of performance, and given the condition of satisfying the customer at all expense, a condition exists for overstockage of initial support items. [4:85]

There remains a clear need for some way to feedback to the provisioner and other logistic managers the effectiveness of initial provisioning support.

F. WEAPON SYSTEM AUTOMATED INFORMATION SYSTEM

MCLBA now plans to incorporate a provisioning effectiveness evaluation system within its current weapon system automated information system development program. The WS/AIS is the USMC response to the 1986 DOD Secondary Item Weapon System Management Concept and Implementation Guide [16]. SIWSM directs the services to implement management, procedural and automated systems to measure performance by weapon system support goals, not secondary item goals.

The SIWSM concept consists of 13 management capabilities, 3 of which pertain to initial provisioning:

- Multi-Echelon Optimization Models. Models must compute repair part requirements based on weapon system availability goals, not secondary item goals;
- Demand/Usage Reporting by Weapon System. Demand and cost history will be broken out in computer reports by weapon system sequence; and
- Performance Tracking. Provisioning performance will be evaluated by weapon system readiness goals, not supply goals. This approach ultimately should lead to better computational techniques. [16:7]

An MCLBA project management team has taken a systems engineering approach to define the conceptual baseline.

major tasks and overall requirements of the system. An initial outlook suggested M3S as a viable alternative to SIWSM concept [17]. Upon closer inspection, however, it was decided that the USMC implementation of SIWSM should be analyzed and evaluated from the standpoint of job functions and task requirements, not from current systems [18]. Regardless of how the development effort proceeds there remains a bona fide need to determine provisioning MOEs and derive the data elements needed for implementation.

III. PROVISIONING MEASURES OF EFFECTIVENESS

A. INTRODUCTION

The mark of a good MOE is whether or not it assesses the objective. Ideally an objective should be well-defined, complete and appropriate to the task at hand. Unfortunately, the objectives of provisioning are vague, multifaceted and often conflicting; therefore the goal of this chapter is to attempt to describe reasonable provisioning objectives and measures. However, no prescription of a hierarchy of objectives will be attempted.

It must be emphasized that problems can arise when no cost-effective method exists to capture the data or aggregate the information to implement an MOE. As a result, a measurable proxy must often substitute for an elusive MOE.

All MOEs will be designed to allow computation by individual weapon system. This is in keeping with the SIWSM goals noted in the last chapter. The time period encompassed by the MOEs will be the entire time period that the IIP was intended to support the weapon system.

Provisioning objectives and MOEs are divided into five categories, each of which will be discussed in more detail:

- Weapon System Readiness
- Supply Support
- Cost
- Essentiality
- Range and Depth

B. WEAPON SYSTEM READINESS

The effectiveness of provisioning should ideally be stated in terms of the readiness of the supported weapon system. DOD's 1986 SWISM concept and implementation guide is a driving document in this regard [16]. The ultimate goal is to maximize equipment readiness by devising a secondary item management scheme which provides computer output reports in weapon system sequence.

Readiness is a bottom line figure used throughout DOD. However, present day supply automated information systems do not link supply performance with weapon system readiness. The SIWSM guide directs the services to develop these links, and thereby relate resources to readiness. Research has uncovered three candidate MOEs to track weapon system readiness.

1. Weapon System Availability

Operational availability (Ao) is the probability that a system or equipment, when used understated conditions in an actual operational environment, will operate satisfactorily when called upon [19:64]. This measure is a composite of inherent availability (Ai) and the effectiveness of the support environment found in the operating forces [20:9].

$$Ao = \frac{MTBF}{MTBF + MTTR + MLDT}$$

The mean time between failure (MTBF) shows the average equipment operating time between failure. The mean time to repair (MTTR) is the average time it takes to repair/restore a weapon system to an operational condition. The mean logistics delay time (MLDT) shows the average time it takes to supply resource support to a deadlined weapon system [21:4]. Repair parts are an important support resource, hence the relationship between initial provisioning and readiness is encompassed in this model.

MLDT is not a precise measure of provisioning because it includes delays which result from the wait for tools, test equipment, transportation and facility space. Nonetheless, the Ao percentage does yield a general bottom line number to help evaluate weapon system readiness. To further isolate the effects of provisioning, a non-availability measure (Np) could be easily computed by subtracting the inherent availability (Ai) from the operational availability where:

$$Ai = \frac{MTBF}{MTBF + MTTR}$$

2. <u>LM2 Unit Readiness</u>

The current Marine Corps FMF measure of equipment readiness is the LM2 percentage. This snapshot shows equipment operational readiness down to the battalion level. To compute this percentage divide the number of weapon systems operationally ready by the total number of weapon systems. A variety of equipment types such as communications, engineers, motor transport and ordnance are combined into a single percentage score. It therefore provides no specific feedback to provisioning effectiveness for a given weapon system.

Fortunately, Marine major commands (Divisions, Wings, FSSGs) also receive a weekly computer output report derived from LM2 files called the Equipment Status Report which provides readiness data aggregated by weapon system. For example, at a glance one could see the aggregated readiness of M60 machine guns. This aggregation, if averaged over several weeks after the material support date, should approximate the Ao measure for evaluating initial provisioning effectiveness.

3. <u>Component Availability</u>

This measure relates weapon system availability to its individual components based on the theory that a system's Ao is the product of the availabilities of its components Ao(Si) [22:3].

$$Ao(Si) = \frac{MTBFi}{MTBFi + MTTRi + MSRTi(Si)}$$

The "i" subscript denotes that the measure applies only to a specific component. MSRTi(Si) is the mean supply response time of each component; MSRT, an approximation of MLDT, considers only the supply system response time part of the logistics delay. The provisioning objective is to maximize Ao(Si) by minimizing MSRT, a variable strongly influenced by provisioning decisions. Even so, the minimization of MSRT does not necessarily yield the same solution as maximizing system availability in forecasting models [22:56]. Unfortunately, system availability is a complicated function which depends on component availability system configuration and system deployment. Thus, the utility of this measure for isolating the effects of provisioning is doubtful.

The four availability measures of operational availability (Ao), non-availability due to provisioning (Np), LM2 readiness and component availability are candidate provisioning MOEs. They are bottom line measures that loosely relate provisioning to readiness.

C. SUPPLY SUPPORT MEASURES

Supply support MOEs show how well the initial parts inventory met the demand for parts. However, not all MOEs directly account for the impact of provisioning upon weapon system readiness.

1. Mean Supply Response Time

Briefly discussed in the last section, MSRT is a surrogate measure of MLDT that isolates the effects of initial provisioning decisions, but excludes the other delays normally associated with MLDT. MSRT captures the average time it takes to satisfy a customer's requisition regardless of the source of supply. It empirically measures IIP effectiveness: if MSRT is low, parts were generally satisfied by the IIP; if MSRT is high, then several requisitions were backordered.

MSRT is not a perfect measure as it ignores the cost and essentiality of parts demanded or supplied. As an aggregate, however, MSRT relates provisioning to weapon system readiness better than any of the following measures.

2. <u>Supply Material Availability</u>

SMA is the percentage of requisitions satisfied on the first pass against system assets [23:1-19]. For provisioning purposes it can be defined as the percentage of requisitions satisfied on the first pass against the IIP. SMA can be expressed in either a range or depth measure.

Range SMA, computed by dividing the number of requisitions satisfied from the IIP by the total number of requisitions received, shows how well the IIP satisfied customer's documents. Since more than one item may be ordered on a document number there is a chance for a partial fill. To measure this, the depth SMA, which divides the number of parts satisfied from the IIP by the total demand for parts, is more appropriate.

While SMA measures the gross range and depth of the IIP, it does not include cost or essentiality measures. Nor does SMA include time delays resulting from backorders, which may be significant.

3. <u>Backorder Percentage</u>

This can be computed in two ways. Either divide the number of backordered documents by the number of documents submitted or subtract the depth SMA from one. The backorder percentage shows a general measure of IIP failure and suffers the same drawbacks as the SMA measure.

4. <u>Average Days Delay for Delayed Requisitions</u>

ADDDR approximates the average number of days it takes for backorders to be filled [23:1-20]. It indirectly measures how well the IIP provides supply support. To compute ADDDR divide MSRT by one minus the range SMA. ADDDR, like other supply performance measures, does not address cost or essentiality.

5. Summary

This section discussed provisioning MOEs in terms of supply performance. Mean Supply Response Time shows the average number of days needed to get parts, regardless of inclusion in the IIP. The Supply Material Availability shows a gross percentage of how well the IIP matched up to actual demand. Its converse, percentage of backorders, gives a gross measure of the IIPs inadequacy in the face of actual demand. Average Days Delay for Delayed Requisitions reflects the severity of the response time when the part was not in the IIP.

D. COST MEASURES

Another way to view provisioning effectiveness is through the eyes of Congress; namely, through cost related measures. These measures try to compare the investment, holding and obsolescence costs of parts to the consequences of not having the parts in the IIP.

Determining the costs due the lack of parts in IIP is impossible. Though we know that for the want of a carburetor a jeep is lost, it is impossible to quantify the cost of not having that jeep on the battlefield. The cost would have to account for its mission, the intensity of need, the availability of other jeeps, and so on. Therefore, our focus is on more commensurable measures which deal with the costs of excess parts or backordering.

1. Investment Costs

The investment cost of the IIP is simply the dollar value of all parts. Ideally, over the IIP support time period, all demand is met by the IIP and all IIP stock is consumed. Rarely does the IIP correlate exactly with actual demand, thus, shortage and overage costs are incurred. The total IIP investment cost does provide a baseline figure to augment the measures discussed below.

2. Order Costs

When demanded parts are not available in the IIP a shortage cost is incurred. The shortage cost consists of two parts, the cost of an inoperable system and the special order processing costs to backorder the part from the wholesale system. As stated earlier the dollar value of an inoperable weapon system will not be computed; insight into the severity of weapon system inoperability can be gained from the Np MOE discussed in section B above. The processing cost per order can be derived empirically or the USMC could use values similar to those used by the Navy or cited in DODI 4140.42 [7:Encl.3]. Order costs include the administrative and processing costs incurred to order parts. The total order cost can be used to show an aggregate dollar value incurred over the specific IIP time period.

This measure is similar to the backorder percentage measure mentioned earlier. Though it might seem that we would want to minimize it, that is not so. Order costs should always be traded-off against the overage costs.

3. Overage Costs

An overage cost is incurred when there is no a demand for an IIP part. The total overage cost includes the cost of holding stock, the obsolescence costs, and the time value cost of the money that was invested in the stock. Holding costs include the warehousing, personnel and materials handling incurred to keep inventory. Like the processing cost per order, the inventory holding rate should be derived empirically and set as a matter of policy. The Navy assumes it to be 21% for consumables and 23% for reparables of the unit cost per year that the item is in inventory. DODI 4140.42 assumes a 20% inventory holding rate [7:Encl.3]. Overage costs can be divided by line items or the number of parts to compute a ratio measure.

4. Overage Percentage

It might also prove useful to divide the dollar value of IIP excesses by the IIP investment cost. Such a percentage would give some perspective of the costs of excesses to the investment made in the inventory.

5. Summary

The three general costs discussed in this section were the investment cost, the order cost and the overage cost. From this discussion four candidate measures emerged. The first was the IIP investment cost which is the dollar value of the IIP. The order cost included the administrative and processing costs to expedite a backorder to the wholesale level. The overage cost included inventory holding costs, obsolescence costs and the opportunity cost of money. Finally the overage cost percentage shows the cost of investing in parts that were not demanded relative to the IIP investment cost.

One drawback of the cost perspective is that it may cause too much attention on the costs of provisioning without equal attention to the benefits derived. The next set of MOEs will deal with the actual utility of IIP parts.

E. ESSENTIALITY MEASURES

The measures discussed thus far do not address the difficult issue of whether the parts are critical[3] to the functioning of the weapon system. The weapon system

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[3] For our purposes the terms essential and critical are synonymous.

readiness, supply performance, and cost MOEs focused on aggregates and percentages without regard for criticality of the parts.

The measurement of repair part criticality is complicated. A 1982 General Accounting Office report stated that a DOD-wide criticality coding scheme does not exist, but that one should [24:1]. The Kiebler and Colaianni criticality coding scheme, sponsored by DOD, has not been adopted [25]. DOD has directed each military service to develop its own criticality coding scheme, however no explicit directive requires integration of these schemes. Thus, even if a coding scheme could be developed, the problem of inter-service incompatibility would continue to exist; this incompatibility would severely impact upon the Marine Corps because many of its weapon systems are procured by other services.

Incorporation of criticality indices has been demonstrated in the Richards and McMasters wholesale provisioning models of MSRT and SMA [22]. Therefore the aforementioned supply support and cost MOEs could incorporate essentiality. Unfortunately, a linear model is required for the essentiality term in the reference [22] models. No such model has been developed as yet by any service. McMasters has therefore proposed that the MSRT, SMA and Cost MOEs presented earlier be used for each essentiality class.

Information concerning the critical composition of the IIP is provided by the next four simple MOEs. For instance the ratio of critical line items, quantities or costs to the corresponding total IIP values all provide insight into how much of the IIP consists of critical parts. Also a measure of the percentage of critical parts which compose IIP shortages would be useful.

Since a comprehensive criticality scheme, such as the one proposed in reference [25], is not available this paper resorts to the NMCS (Not Mission Capable, Supply) and the combat essentiality code data elements in current USMC automated files. FMF personnel assign an NMCS indicator when, in their judgment, the want of that part deadlines or severely degrades the operation of a readiness reportable weapon system. CEC codes are assigned by MCLBA personnel during the initial source coding of secondary items; a CEC code of 4 or 5 designates a secondary item as critical to the operation of its weapon system. Normally, but not always, NMCS indicators are assigned only to CEC 4 or 5 coded part requisitions.

F. RANGE AND DEPTH MEASURES

Initial issue provisioning can be categorized into range and depth decisions. Range is the choice of whether or not to include a part in the IIP. Depth is the choice of how many units of a part to include. The supply support MOEs discussed earlier give some indication of IIP range and depth effectiveness. In this section a slightly different perspective to IIP range and depth is presented.

One minus the ratio of the number of line items demanded to the total number of IIP line items would show the percentage of no-range demand. Substituting number of units demanded for line items and the total number of units of each item in the above ratio would show a percentage of no-depth demand.

These simple measures give a general idea of the utility of the IIP. They could be further subdivided into percentage NMCS of range and depth to examine the utility of critical parts in the IIP.

G. SUMMARY

This chapter discussed five general categories of provisioning measures of effectiveness: weapon system readiness, supply support, cost, essentiality, and range and depth. While no MOE satisfies all five criteria, Congress and DOD prefer measures that relate resources (i.e.,total investment) to readiness.

In keeping with the overriding objectives of SIWSM and the USMC Provisioning Manual all MOEs should be computed by individual weapon systems. Table I summarizes the candidate measures.

TABLE 1

CANDIDATE MEASURES OF EFFECTIVENESS

READINESS

1. Weapon System Availability (Ao)
2. Non-availability, Provisioning (Np)
3. LM2 Percentage
4. Component Availability (Ao(Si))

SUPPLY SUPPORT

1. Mean Supply Response Time (MSRT)
2. Supply Material Availability (SMA)
3. Backorder Percentage (BO%)
4. Average Days Delay for Delayed Requisition (ADDDR)

COST

1. Investment Cost
2. Order Cost
3. Overage Cost
4. Overage Percentage

ESSENTIALITY

1. Critical IIP, Range
2. Critical IIP, Depth
3. Critical IIP, Dollar Value
4. Critical IIP, Shortage

RANGE AND DEPTH

1. Percentage No-Range Depth
2. Percentage No-Depth Demand

IV. PROVISIONING DATA ELEMENTS

This chapter explores the data elements necessary for automated computation of the MOEs presented in the previous chapter. It begins by analyzing data elements resident in USMC automated files. For deficiencies identified, proposals for refinement of existing elements or creation of new data elements are presented. Appendices B, C, D and E are a compendium of this chapter.

A. READINESS DATA

1. Weapon System Availability

For weapon system availability it will be useful to compute two numbers, operational availability (Ao) and the percentage of nonavailability due to lack of parts (Np). Np is the difference between Ao and inherent availability (Ai). The relevant formulas are:

$$Ao = \frac{MTBF}{MTBF + MTTR + MSRT} \tag{1}$$

$$Ai = \frac{MTBF}{MTBF + MTTR} \tag{2}$$

$$Np = Ao - Ai \tag{3}$$

MTBF and MTTR represent reliability and maintainability measures determined by system engineering design decisions and are thus beyond the control of the provisioner. MSRT is chosen as a surrogate measure of mean logistic delay time (MLDT) for two reasons. First, because it depicts a measure related to the inventory of repair parts. Next, it is easier to calculate the MSRT.

a. Mean Time Between Failure

The Marine Corps Integrated Maintenance Management System (MIMMS) defines MTBF as the average equipment operation between equipment failures [26:A-14]. Equipment operation is expressed by the equipment operating time code (EOTC) which can be in units of days, hours, rounds or miles depending on the type of equipment involved.

$$MTBF = \frac{\text{Sum of EOT Between Failures}}{\text{Number of Failure Actions}} \quad (4)$$

Even if EOTC values are in rounds or miles, the MTBF must be in units of time to be compatible with MTTR and MSRT. Two remedies are offered. First, an MTBF expressed in miles could be converted to time units by use of a conversion factor, say, 42 miles per day for example[4]. Thus an MTBF of 6000 miles would be equivalent to an MTBF of 142.86 days which could then be commensurate with MTTR and MSRT. This approach is sensitive to the choice of a conversion factor, which should be derived empirically for each case when the EOTC is not in time units.

A different approach computes MTBF in days, not in hours, miles or rounds and uses other data resident in the MIMMS/AIS ERO History File:

$$MTBF = \frac{\text{Sum of (DCD1 - ERO CLOS DATE1)}}{\text{\# Deadlined ERO's}} \quad (5)$$

For each deadlined equipment repair order (ERO)[5] the

4. This is an arbitrarily chosen factor based on the rough estimate that a truck averages 15000 miles per year. (15000 miles/365 days is about 42 miles per day).

5. The ERO is the standard maintenance work order document to record all required maintenance information and authorize the requisitioning of parts. Data from the ERO is entered into MIMMS/AIS. A category code of M or P designates a weapon system as deadlined.

deadline control date (DCD) is compared to the date the previously deadlined ERO (for the same serial number) was taken off deadline status. The ERO date is computed by adding the actual number of days deadlined (DDL) to the original DCD.

The maintenance history of an M60 machine gun provides an example. Its most recent DCD was julian date[6] 7300. A look at the previous deadlined ERO for this machine gun reveals a DCD of 7050 and the number of DDL as 25. So to find the time between failure (TBF) the equation would be 7300 - (7050 + 25) which results in a TBF of 225 days. Sum the TBFs for all instances of failure and all serial numbers. The average of these values would be the MTBF.

To compute MTBF using either equation (4) or (5) simply sum the times between failure, then divide by the actual number of failures (deadlined EROs). Formula (5) uses data available in MIMMS/AIS, but does not account for actual usage (i.e., number of rounds fired) of a weapon system. Thus, either method chosen to compute MTBF will be an approximation. The first is sensitive to the choice of a conversion factor, while the second is sensitive to usage variation.

By definition, MTBF is concerned with failure actions and accounts only for unscheduled corrective maintenance. It will be used for both the Ao and the Ai availability measures.

All data elements required for computation of MTBF are in the ERO History File and include:

CAT_CD	DDL	DCD
EOTC	ERO_CLOS_DATE	ERO_NR
ID_NR	SER_NR	

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6. The julian date is a four-digit number which expresses the year and the day of the year. For instance January 23, 1987 would be a julian date of 7023, showing it as the 23rd day of 1987.

The computations include:

1. Sum of EOT between failures (EOTBF).
2. Multiply EOTBF by the conversion constant.
3. Count of Deadlined EROs (Cat Code = either M or P with a DCD).
4. Divide the product from step 2 by the result of step 3 (MTBF).

b. Mean Time to Repair

MIMMS defines the mean time to repair as the average number of maintenance man-hours expended in repairing an item which requires corrective maintenance (CM) [26:A-14].

$$MTTR = \frac{\text{Sum of CM Man-Hours}}{\text{\# CM Actions}} \qquad (6)$$

This formula computes a result in time units, but it may be inaccurate due to the method of calculating CM man-hours. The ERO history file can only store three maintenance actions (by defect code (DEF_CD) and associated military labor hours (MIL_LAB_HRS)) for each ERO. Current procedures permit non-critical and preventive maintenance accomplishments to appear on the same ERO. Also, more than three maintenance actions can be recorded on the paper ERO. So, to accurately compute MTTR, a coding scheme would have to link specific defect codes with CM. No such scheme now exists. A revised formula is therefore proposed to compute an approximate MTTR:

$$MTTR = \frac{\text{SUM of MIL-LAB-HRS}}{24 * (\text{\# Deadlined EROs})} \qquad (7)$$

This measure may include some preventive maintenance labor hours. However, it is felt that they will be insignificant so this approximation should meet our purpose.

The computations for formula (7) require counting the number of deadlined EROS for a specific Item Designator Number (ID_NR) to provide the denominator.

An ID_NR uniquely identifies a particular type of weapon system. The numerator is the sum of the military labor hours. The constant 24 converts the hour measure into days. Inherent availability, Ai, can now be computed using the MTBF and MTTR values in formula (2).

All data elements needed to compute MTTR reside in the ERO History File:

CAT_CD	ERO_NR	ID_NR
MIL_LAB_HRS		

The computational steps are:

1. Sum MIL LAB HRS for all deadlined EROs.
2. Count the number of deadlined EROs.
3. Divide the result of step 1 by the result of step 2.
4. Divide the result of step 3 by 24 to convert MTTR to a day value.

c. Mean Supply Response Time

To compute the denominator of operational availability, Ao, the mean logistic delay time (MLDT) must be computed. As stated earlier, MLDT involves all the delays that inhibit equipment operation due to lack of resources. Only one resource, repair parts, is of interest here. Hence MSRT is chosen as a surrogate for MLDT. Neither MLDT nor MSRT is defined in MIMMS. A review of MIMMS data elements suggests two possible approaches to compute MSRT. The first divides the total time that an ERO was awaiting parts by the number of deadlined EROs.

$$MSRT = \frac{\text{Sum of Days SHT\_PRTS}}{\text{\# Deadlined EROS}} \qquad (8)$$

The deadlined ERO count is the same number used in the MTBF and MTTR computations. To compute the number of days short parts subtract the julian date the ERO was placed in a SHT_PRTS status from the julian date of the subsequent job status for that ERO.

For example, if an ERO was placed in a short parts status on julian date 7200 and the julian date of the next job status was 7225, then the number of days in a short parts status for this ERO would be 25 days. Sum these values to arrive at the numerator.

Formula (8) gives a worst case value because it includes both the administrative processing time as well as the longest delay for any part. Suppose 10 parts were ordered and 9 arrived in 3 days but the other part arrived in 30 days. Then the number days in a SHT_PRTS status for that ERO would be at least 30 days even though most parts arrived in less than 30 days.

A second method of computing MSRT determines the average requisition response time. Two files, the provisioning file and the ERO/DOC file, must be created. The provisioning file provides a baseline list of IIP parts information while the ERO/DOC file contains the actual parts demand history over the IIP time period[7].

Since IIP parts information is not now resident in MIMMS or SASSY files, the provisioning file would have to be constructed from a weapon system's Initial Issue Control File which is described in reference [3]. The provisioning file will contain only the CEC code, ID number, national stock number (NSN), quantity and unit price (U/P).

Parts demand history from the MIMMS/AIS Document Status file is needed next. A sub-file, the ERO/DOC File, must be created which will first separate all deadlined EROs by ID_NR of interest. The ERO numbers of this file are then matched to the ERO numbers of the Document Status File. This results in a list of all document numbers for EROs for a particular weapon system. To ensure that only IIP parts are used in computations, include only the document numbers of those actual demand

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[7] Appendix C describes all created sub-files discussed in this chapter.

national stock numbers (NSNa) which match a provisioning list national stock number (NSNp).

$$MSRT = \frac{\text{Sum of (RCVD DATE - DOC DATE)}}{\text{Total \# Documents}} \qquad (9)$$

For each document number, subtract the date the parts were ordered (DOC_DATE) from the date the parts were received (RCVD_DATE) by the using unit. Sum these differences to get a numerator called the total supply response time (TSRT). Count the documents to arrive at the denominator. Thus MSRT is the average time delay awaiting parts for deadlined weapon systems.

Two files are needed for these computations:

ERO/DOC file
Provisioning file

The data elements needed to generate MSRT are:

DOC_DATE	DOC_NR	ERO_NR
ID_NR	NSN	RCVD_DATE

The computational steps are:

1. Include only document numbers for which NSNa = NSNp.
2. Subtract DOC_DATE from RCVD_DATE.
3. Sum the differences in step 2 to get TSRT.
4. Count the number of documents.
5. Divide TSRT by the number of documents.

MSRT is the final value needed to compute operational availability, Ao, using formula (1). Ao will be MOE 1.1. Another MOE, formula (3), represents the percentage of weapon system non-availability due to the wait for repair parts (Np). Np will be MOE 1.2.

2. LM2 Readiness

The USMC uses the Marine Automated Readiness Evaluation System to assess equipment readiness. MARES is a weekly snapshot of the deadline rate and includes only Marine Corps Bulletin 3000 designated items [27]. It is therefore a subset of the ERO History file. Since only some, not all, new weapon systems are tracked, the LM2 measure is insufficient for our purposes. Note, however, that the LM2 algorithm to compute readiness could be modified to include category code P EROs; in that case it would then approximate the Ao measure discussed earlier as it would include all new weapon systems.

It would not be possible to produce a measure similar to Np because LM2 data cannot compute specific MTBF, MTTR or MSRT measures. Therefore the Ao and Np measures are preferred.

3. Parts Availability

The parts availability measure Ao(Si) is of limited utility because current databases are not designed to capture pertinent data. Actual part failure data is needed to compute this measure. Under current procedures some parts are replaced before they fail, other parts may fail but not degrade weapon system availability and so are not replaced immediately. Further, an MSRT for each reparable can not be measured because demand for reparables is not traceable to a specific weapon system (for example, an alternator may be common to a whole fleet of motor vehicles). Due to the extreme difficulty in developing data for this measure it will not be further considered.

4. Summary

Weapon system readiness measures, Ao and Np, can be implemented with existing data and minor procedural changes in MIMMS/AIS files. The LM2/MARES measure could also be used but needs a minor modification to include all new weapon systems. Finally, the parts availability model would require new data elements and the associated collection procedures.

B. SUPPLY SUPPORT DATA

1. Mean Supply Response Time

The MSRT discussed earlier is a good starting point for a gross supply support measure. It can be further subdivided into more specific measures.

First, it can be segregated into an MSRT for consumables and an MSRT for reparables. To do this sort the ERO/DOC file by advice code (ADV_CD). Put all documents with an advice code of 2_ into a separate sub-file (ERO/DOC/CON file) for consumables, and put all documents with an advice code of F_ into the ERO/-DOC/REP sub-file for reparables. Then compute an MSRT for each sub-file. The computational steps for MSRT will be the same as in formula (9), but two other sub-files must be substituted for the ERO/DOC file:

ERO/DOC/CON file
ERO/DOC/REP file

In addition to the data elements for MSRT cited above, one more is needed:

ADV_CD

The numbering for MOEs will be:

MOE 2.1a Total MSRT (MSRTt)
MOE 2.1b Consumable MSRT (MSRTc)
MOE 2.1c Reparable MSRT (MSRTr)

2. Supply Material Availability

The supply material availability measure compares the provisioning file to one of the ERO/DOC files. First, a total SMA would be desirable, then a breakdown by consumables and reparables would be appropriate. Each category could be further subdivided into range and depth measures.

First, compare the provisioning list to the ERO/DOC file to find every national stock number match between the provisioning list (NSNp) and the actual demand (NSNa) for the IIP time period. This number will be the numerator. The denominator is the count of NSNa.

$$SMA\_,r = \frac{\text{Total Range Match}}{\text{Count of NSNa}} \tag{10}$$

The same steps could be performed using the ERO/DOC/CON and ERO/DOC/REP sub-file instead of the ERO/DOC file.

The "_" after the SMA in the above formula denotes that a total, consumable or reparable SMA can be computed. Thus the range SMA could be sub-divided out into a consumable and a reparable measure (SMAc,r and SMAr,r).

A depth SMA necessitates a more elaborate procedure. The formula is shown below.

$$SMA\_,d = \frac{\#\ \text{Depth Supplied by IIP}}{\text{Total Quantity Demanded}} \qquad (11)$$

First, sort the ERO/DOC file by NSN. If an NSN appears more than once the quantities must then be summed to create a new ERO/DOC/SUM file. This file will then be compared to the provisioning file. Regardless of whether there is an NSN match or not, subtract the provisioning list quantity (Qp) from the actual quantity demanded (Qa) for each NSN of actual demand. Call this number Qap. Sum all Qap where Qap > 0 and call this total depth shortages. Sum all Qa and call this the total quantity demanded. Subtract the total depth shortages from the total quantity demanded to find the # depth supplied IIP, the numerator. To find SMA, divide the # depth supplied IIP by the total quantity demanded. Substitution of consumable or reparable sub-files results in an SMA consumable or reparable depth measure.

The numbering for SMA MOEs is:

MOE 2.2a Total SMA Range (SMAt,r)
MOE 2.2b Total SMA Depth (SMAt,d)
MOE 2.2c Consumable SMA Range (SMAc,r)
MOE 2.2d Consumable SMA Depth (SMAc,d)
MOE 2.2e Reparable SMA Range (SMAr,r)
MOE 2.2f Reparable SMA Depth (SMAr,d)

The additional data element needed is: QTY

The files needed to compute these measures are:

ERO/DOC file
ERO/DOC/CON file
ERO/DOC/REP file
ERO/DOC/SUM file
ERO/DOC/CON/SUM file
ERO/DOC/REP/SUM file
Provisioning file

Each MOE will produce a value between 0 and 1 with an SMA value of 1 indicating all demands were satisfied from by IIP.

3. Backorder Percentage

The backorder percentage, which can be computed by subtracting any of the depth SMA percentages from 1, will be called MOE 2.3.

4. ADDDR

Average Days Delay for Delayed Requisitions is computed by dividing the MSRT by one minus the total range SMA. ADDDR will be MOE 2.4.

5. Summary

This section resulted in four generic supply support MOEs. The MSRT and the SMA were sub-divided into total, consumable and reparable measures. The backorder percentage and the ADDDR used results from MSRT and SMA calculations.

C. COST DATA

1. Investment Cost

The total investment cost is the total IIP dollar value. Using the data from the provisioning file, multiply each Qp by the unit price and call this PQp. Sum all PQp to arrive at the investment cost. Even though money spent for parts may not equate to effectiveness achieved, for purposes of consistency the investment cost will be called MOE 3.1.

2. Order Cost

Determination of an order cost begins with a comparison of actual parts demanded to the IIP depth. First execute the same procedures discussed in the depth computation of the SMA MOE; that is, subtract the provisioned quantity from the actual quantity demanded to get a Qap value. This value would be greater than 0 when the IIP quantity was less than the actual quantity demanded (shortage) and less than 0 when the IIP quantity was in excess of actual demand (overage). For shortages, parts would have to be backordered and a special backorder cost per order would be used to compute an order processing cost. This standard cost would have to be incorporated into the software program that computes provisioning effectiveness. Multiply the cost per order by the number of parts (sum of all Qp for Qp > 0) to arrive at an order cost for the weapon system. This will be MOE 3.2.

3. Overage Cost

To compute the overage cost, include only NSNs for which Qap < 0. These represent the excess parts at the end of the IIP time period. For each part, add the investment cost (PQp) to the absolute value of the excess parts dollar value (PQap); divide this sum by 2 to arrive at an average dollar value of inventory (PQi) for the IIP time period. Sum all PQi to arrive at the average dollar value of the entire IIP for the IIP time period.

Multiply the sum of all PQi by the inventory holding rate (K2) and by the IIP time period to arrive at the overage cost. The inventory holding rate, like the backorder cost per order, would be contained in the software program that computes provisioning effectiveness. The overage cost is MOE 3.3.

It should be obvious that both the order and overage MOE could be further separated into MOEs for consumables or for reparables although these were not mentioned in Chapter III.

4. Overage Percentage

To evaluate the impact of slow movers compare the investment cost of excess parts to the IIP investment cost. To accomplish MOE 3.4 divide the dollar value of the parts remaining in the IIP (the absolute value of PQap for all PQap < 0) by the total investment cost.

5. Summary

The four MOEs discussed in this section are:

MOE 3.1 Investment Cost
MOE 3.2 Order Cost
MOE 3.3 Overage Cost
MOE 3.4 Overage Percentage

Cost computations require these additional data elements:

U/P
Cost per Order (K1)
Inventory Holding Rate (K2)

The files needed for the computations are:

ERO/DOC file
Provisioning file

Two reminders are warranted. Both the order cost the overage cost are sensitive to the constants chosen; they should therefore be derived from empirical data. Finally, the cost measures cited show only the dollar cost associated with expedited backordering and holding of inventory, not the costs of inoperable weapon systems.

D. ESSENTIALITY DATA

The goal of a essentiality measure is to focus attention on those parts that render a weapon system inoperable. It is therefore a subset of parts files discussed thus far. A key to computation is to accurately devise a way to sort the provisioning file or one of the ERO/DOC files into sub-files that contain only critical parts. From the provisioning file the combat essentiality code (CEC) could be used. This presumes, of course, that the codes have been assigned accurately (which may not be the case, as was observed in references [4], [13] and [25]).

The CEC is not included in a parts document number. So the ERO/DOC files must be sorted to include only documents with a NMCS indicator of N or 9. An NMCS indicator is assigned by FMF maintenance personnel to highlight those parts that deadline a weapon system. This designation need not be limited to CEC critical parts, so there is a possibility of data inconsistency.

Using CECs and NMCS indicators, sub-files can be created to compute any of the aforementioned MSRT, SMA or cost MOEs for critical parts. The computations would be identical, but the files would include only parts designated as critical.

Four other measures may be useful to evaluate the IIP in terms of criticality. The first is the ratio of critical IIP range to the total IIP range. Next would be the ratio of critical IIP depth to total IIP depth. A third would be a ratio of the dollar value of IIP critical parts to the total dollar value of the IIP. Only the PROV/CRIT sub-file is needed for these MOEs.

A fourth measure suggested is the ratio of the quantity of critical IIP shortages to the total quantity of IIP shortages. This compares the provisioning and ERO/DOC critical sub-files using the steps cited in formula (10) earlier.

In summary, four essentiality MOEs were presented:

MOE 4.1 Percentage IIP Critical, Range
MOE 4.2 Percentage IIP Critical, Depth
MOE 4.3 Percentage IIP Critical, Dollar Value
MOE 4.4 Percentage IIP Critical, Shortages

Two additional data elements required for these computations are:

CEC NMCS

The files needed to compute these MOEs:

ERO/DOC/CRIT file
PROV/CRIT file

E. RANGE AND DEPTH DATA

The MSRT and SMA measures reflect range and depth impacts, however it could prove useful to view range and depth in other ways.

One might be to show the IIP range that was not demanded. To do this count all NSNs on the provisioning list which do not match any ERO/DOC file NSN. This is the numerator and will be called no-demand, range. The denominator would be a count of NSNp. This MOE shows the percentage of no-demand, range.

To find the same type of measure regarding depth, sum the quantities of all items where the Qap > 0 to get the numerator. Divide this amount by the sum of all Qp to arrive at the percentage of no-demand, depth.

The two range and depth MOEs are:

MOE 5.1 Percentage No-Demand, Range
MOE 5.2 Percentage No-Demand, Depth

No additional data elements are needed to compute these MOEs. The files required are:

ERO/DOC file
Provisioning File

F. SUMMARY

Candidate measures of effectiveness were analyzed for practical implementation by examining the availability and appropriateness of data elements resident in USMC maintenance and supply files. Table 2 summarizes the 23 MOEs which are feasible to compute and therefore desired for implementation.

TABLE 2

PROPOSED MEASURES OF EFFECTIVENESS

READINESS

1.1 Weapon System Availability (Ao)
1.2 Non-availability, Provisioning (Np)

SUPPLY SUPPORT

2.1a Total Mean Supply Response Time (MSRTt)
2.1b Consumable MSRT (MSRTc)
2.1c Reparable MSRT (MSRTr)
2.2a Total SMA, Range (SMAt,r)
2.2b Total SMA, Depth (SMAt,d)
2.2c Consumable SMA, Range (SMAc,r)
2.2d Consumable SMA, Depth (SMAc,d)
2.2e Reparable SMA, Range (SMAr,r)
2.2f Reparable SMA, Depth (SMAr,d)
2.3 Backorder Percentage (BO%)
2.4 Average Days Delay for Delayed Requisitions (ADDDR)

COST

3.1 Investment Cost
3.2 Order Cost
3.3 Overage Cost
3.4 Overage Percentage

ESSENTIALITY

4.1 Percentage IIP Critical, Range
4.2 Percentage IIP Critical, Depth
4.3 Percentage IIP Critical, Dollar Value
4.4 Percentage IIP Critical, Shortages

RANGE AND DEPTH

5.1 Percentage No-Demand, Range
5.2 Percentage No-Demand, Depth

V. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

A. SUMMARY

Several alternative criteria and MOEs regarding the USMC provisioning effort were investigated. Twenty-three specific measures of effectiveness resulted from this thesis.

A review of DOD and USMC directives establish the goals of provisioning, policy guidance and general background information. The responsibilities of HQMC, MCLBA and the FMF were outlined and the pertinent aspects of the MCLBA WS/AIS development effort were described.

Five general categories of MOEs were presented. Several possible candidate concepts were reviewed and the relative merits of each were analyzed. Particularly problematic and confounding areas received special emphasis. An initial list of desirable MOEs was produced.

The practical implementation of MOEs was considered by defining the data elements and the sub-files needed for computation. Using USMC automated maintenance and supply files as a starting point, data elements were identified, modified and manipulated. The resulting list furnishes a basis for immediate MOE implementation at a reasonable cost.

Appendices B, C, D and E condense the significant results of the thesis. All data elements are defined, proposed sub-files are described, and an MOE/data element matrix is presented.

B. CONCLUSIONS

CMC has directed the MCLBA to implement a provisioning effectiveness evaluation system. Given this edict, MCLBA must opt for the best implementation approach as well as determine specific measures. To contribute to this effort, the following conclusions are offered:

1. Five generic categories emerge as desirable provisioning objectives: weapon system readiness, supply support, cost, essentiality and range and depth.
2. No category or specific MOE is fault free. All have merits and drawbacks. Therefore, consideration must be given to whose information needs can best be met by implementing any of the stated MOEs.
3. The weapon system readiness measures, Ao and Np, are the only MOEs that relate provisioning to availability. Despite its perceived desirability as a resources to readiness metric, the connection is weak at best. A further disadvantage accrues in that data elements now resident in USMC computer files must be modified to accommodate these MOEs.
4. The two supply support measures, MSRT and SMA, pertain more directly to provisioning effectiveness. MSRT demonstrates supply responsiveness while proposed SMAs give various batting averages of IIP performance. These measures can be computed from current data elements and files, but no direct relationship to readiness can be ascribed to SMA.
5. Cost MOEs put a dollar value on IIP shortfalls and excesses. The investment cost shows the IIP dollar value. The order cost puts a value on expedited backorders and should include the cost of inoperable weapon systems. However, this latter cost is impossible to determine. Inventory holding costs are an integral part of the overage cost MOE. Finally, the overage percentage depicts the ratio the of dollar value of excess to total the investment cost.
6. MOEs involving essentiality are almost as important as the readiness measures. MSRT and SMA measures

could be of even greater usefulness if they included only the critical repair parts that render a weapon system inoperable. The main drawback of current essentiality measures is suspect data integrity because of the methodology of CEC and NMCS indicator assignment.

7. Range and depth MOEs show IIP ineffectiveness. They may provide useful data to meet headquarters reporting requirements, but are of questionable value as feedback to provisioners.

C. RECOMMENDATIONS

This thesis examined but one part of a large, complex provisioning endeavor. Three further areas for research and action have emerged from this study.

1. The DOD SIWSM guide, a fertile repository for logistic research and development, directs far-reaching conceptual changes to USMC management and reporting systems. Two particularly problematic issues encountered, and encompassed in SIWSM, deserve further research. First, weapon system availability measures should be refined to isolate the contribution of resource support (i.e., repair parts) to readiness. Secondly, quantifying the cost of an inoperable weapon system would serve not only to improve the shortage cost MOE, but also would provide better estimates of the risk of shortages (i.e. the lambda parameter of the COSDIF model [7: Encl. 3]) for provisioning forecasting models.
2. The complexity of data relationships needed for the MOE computation requires considerable file processing time. Therefore, as it relates to this subject matter, a relational database with simple query procedures better suits the task. As such,

it is presented as an important alternative to consider for WS/AIS system development.

3. A next logical step, and possible thesis topic, is to design a relational database and the corresponding software which provide output reports to implement the aforementioned MOEs.

Implementation of MOEs is another step toward improvement of USMC provisioning policy. Since these MOEs are after-the-fact, it will be too late to affect the initial repair part provisioning for the evaluated weapon system. Thus, the lessons learned from MOEs will have to be applied to new weapon systems. Ultimately, the best MOE should be utilized as the objective function for Marine Corps provisioning forecasting models. Operations research optimization techniques, similar to those in reference [22], can then be used to determine both the range and depth of IIPs.

APPENDIX A

GLOSSARY OF ACRONYMS

ADDDR	Average Days Delay for Delayed Requisitions
Ai	Inherent Availability
AIS	Automated Information System
Ao	Operational Availability
BO	Backorder
CEC	Combat Essentiality Code
CM	Corrective Maintenance
CMC	Commandant of the Marine Corps
DCD	Deadline Control Date
DDL	Days Deadlined
DOD	Department of Defense
EOTC	Equipment Operating Time Code
ERO	Equipment Repair Order
FMF	Fleet Marine Force
GOL	Garrison Operating Level
HQMC	Headquarters Marine Corps
ID	Item Designator
IIP	Initial Issue Provisioning
LSA	Logistic Support Analysis
MARES	Marine Automated Readiness Evaluation System
MCLBA	Marine Corps Logistics Base, Albany, Georgia
MIMMS	Marine Corps Integrated Maintenance Management System
M3S	Marine Corps Standard Supply System
MLDT	Mean Logistic Delay Time
MOE	Measure of Effectiveness
MSRT	Mean Supply Response Time
MTBF	Mean Time Between Failure
MTTR	Mean Time to Repair

MUMMS	Marine Corps Unified Materiel Management System
NMCS	Not Mission Capable, Supply
Np	Non-availability due to provisioning
NSN	National Stock Number
NSO	Numeric Stockage Objective
OST	Order and Ship Time
PCLT	Procurement Leadtime
PTD	Provisioning Technical Documentation
PWR	Pre-positioned War Reserve
SIWSM	Secondary Item Weapon System Management
SMA	Supply Materiel Availability
USMC	United States Marine Corps
U/P	Unit Price

APPENDIX B

DATA DEFINITIONS

The following is an alphabetical list of the data elements needed to compute the proposed MOEs. An asterisk indicates a data element not now resident in USMC files. Refer to the numbering in Appendix C to cross-index the data elements with the files where used.

1. Advice Code

   ACRONYM: ADV_CD

   FORMAT: alpha-numeric

   LENGTH: 2

   FILES WHERE USED: 4,5,7,8

   DESCRIPTION: A two-digit code assigned by the originator to request supply action be taken by the processing point.

2. Category Code

   ACRONYM: CAT_CD

   FORMAT: alpha-numeric

   LENGTH: 1

   FILE WHERE USED: 1

   DESCRIPTION: A one character code which identifies the type of equipment and criticality of repair.

3. <u>Combat Essentiality Code</u>

ACRONYM: CEC

FORMAT: alpha-numeric

LENGTH: 1

FILE WHERE USED: 11

DESCRIPTION: A one-digit code which designates the criticality of the part to its weapon system.

4. <u>Cost Per Order</u>*

ACRONYM: K1

FORMAT: dollar

LENGTH: 6

FILES WHERE USED: Not part of a file per se, but used for shortage cost computations. Must be included in software to compute order cost MOE.

DESCRIPTION: A dollar value which denotes an average processing cost for each backorder document.

5. <u>Days Deadlined</u>

ACRONYM: DDL

FORMAT: numeric

LENGTH: 3

FILE WHERE USED: 1

DESCRIPTION: The total number of days that a weapon system was reported inoperable (deadlined).

6. <u>Deadline Control Date</u>

ACRONYM: DCD

FORMAT: julian date

LENGTH: 4

FILE WHERE USED: 1

DESCRIPTION: The date the weapon system was reported inoperable.

7. Defect Code

ACRONYM: DEF_CD

FORMAT: alpha-numeric

LENGTH: 3

FILE WHERE USED: 1

DESCRIPTION: A three character code to identify specific problems for equipment inducted for repair. The first position identifies the major sub-system involved, the other two positions relate to the specific defect.

8. Document Date

ACRONYM: DOC_DATE

FORMAT: julian date

LENGTH: 4

FILES WHERE USED: 2 through 9

DESCRIPTION: The date the requisition was entered into the supply system. Contained within the 5th through 8th digit of the document number.

9. Document Number

ACRONYM: DOC_NR

FORMAT: alpha-numeric

LENGTH: 14

FILES WHERE USED: 2 through 9

DESCRIPTION: A unique code to identify a requisition during the entire supply processing cycle. Consists of the requisitioner's accounting number, julian date (see DOC_DATE), and a unique serial number.

10. Equipment Operating Time Code

ACRONYM: EOTC

FORMAT: alpha-numeric

LENGTH: 1

FILE WHERE USED: 1

DESCRIPTION: A one character code to indicate whether units of operation is measured in days, hours, miles, or rounds.

11. Equipment Repair Order Number

ACRONYM: ERO_NR

FORMAT: alpha-numeric

LENGTH: 5

FILES WHERE USED: 1 through 9

DESCRIPTION: A unique five character code assigned to a work request to identify the cost of maintenance performed.

12. ERO Close Status Date

ACRONYM: ERO_CLOS

FORMAT: julian date

LENGTH: 4

FILE WHERE USED: 1

DESCRIPTION: The date the ERO was terminated.

13. Inventory Holding Rate*

ACRONYM: K2

FORMAT: percentage

LENGTH: 2

FILES WHERE USED: Not part of a file per se, but used for overage cost computations. Must be included in software to compute either of the overage cost MOEs.

DESCRIPTION: A value between 0 and 1 to denote an cost of holding inventory over a year.

14. Item Designator Number

ACRONYM: ID-NR

FORMAT: alpha-numeric

LENGTH: 6

FILES WHERE USED: 1 through 11

DESCRIPTION: A number which uniquely identifies any weapon system (i.e., all M60 tanks).

15. Job Status Code

ACRONYM: JOB_STAT

FORMAT: alpha-numeric

LENGTH: 2

FILE WHERE USED: 1

DESCRIPTION: A code which to describes the status of equipment undergoing repair.

16. Military Labor Hours

ACRONYM: MIL_LAB_HRS

FORMAT: numeric

LENGTH: 4

FILE WHERE USED: 1

DESCRIPTION: The accumulated hours incurred for the repair of a weapon system. Includes both direct maintenance and shop overhead hours.

17. National Stock Number

ACRONYM: NSN, NSNa, NSNp

FORMAT: alpha-numeric

LENGTH: 13

FILES WHERE USED: 2 through 11

DESCRIPTION: The stock number to uniquely identify all parts in the DOD supply system, This thesis used the abbreviations NSNa for actual demand and NSNp for provisioned repair parts.

18. Not Mission Capable Supply

ACRONYM: NMCS

FORMAT: alpha-numeric

LENGTH: 1

FILES WHERE USED: 2, 3 and 9

DESCRIPTION: A material condition indicating a weapon system is deadlined or degraded due to supply shortage.

19. Quantity

ACRONYM: QTY, Qa, Qp

FORMAT: numeric

LENGTH: 2

FILES WHERE USED: 2, 3 and 6 through 11

DESCRIPTION: The number of parts for each NSN. This thesis used the abbreviations Qa for parts requested and Qp for parts in IIP.

20. Received Date

ACRONYM: RCVD_DATE

FORMAT: julian date

LENGTH: 4

FILES WHERE USED: 2 through 9

DESCRIPTION: The date the ordered repair part was received by the requesting unit.

21. Serial Number

ACRONYM: SER_NR

FORMAT: alpha-numeric

LENGTH: 8

FILE WHERE USED: 1

DESCRIPTION: A number to uniquely identify a specific weapon system (i.e., one particular M60 tank).

22. <u>Unit Price</u>

ACRONYM: U/P

FORMAT: dollar

LENGTH: 8

FILES WHERE USED: 10,11

DESCRIPTION: The price of one unit of issue of a particular national stock number.

APPENDIX C

FILE STRUCTURE DEFINITION

This appendix relates the data elements to recommended files and sub-files. Two of the files, the ERO History File and the Document Status File, exist now. Various combinations and subsets of these files compose the sub-files needed for many of the computations. The provisioning file, while not in the current USMC database structure could be added. The data needed is formulated following the procedures in Chapter VI of reference [3]. Note that in a relational database configuration, the sub-file structures could be generated dynamically from the base tables (files).

1. ERO History File

   DATA ELEMENTS: CAT_CD, DDL, DCD, DEF_CD, EOTC, ERO_NR, ERO_CLOS, ID_NR, JOB_STAT, MIL_LAB_HRS, SER_NR

   APPLICABLE MOEs: 1.1, 1.2

   DESCRIPTION: The primary maintenance information file of MIMMS/AIS.

2. DOCUMENT STATUS FILE

   DATA ELEMENTS: DOC_DATE, DOC_NR, NSNa, NMCS, Qa, RCVD_DATE

   APPLICABLE MOEs: 1.1, 1.2

   DESCRIPTION: The primary repair part file of MIMMS/AIS.

3. ERO/DOC FILE

DATA ELEMENTS: ADV_CD, DOC_DATE, DOC_NR, ERO_NR, ID_NR, NSNa, RCVD_DATE

APPLICABLE MOEs: 1.1, 1.2, 2.1a, 2.2a, 2.3, 2.4, 3.2, 3.3, 3.4, 5.1, 5.2

DESCRIPTION: A file which marries the range of demanded repair parts documents to specific weapon systems using ERO_NR as a key.

4. ERO/DOC/CON FILE

DATA ELEMENTS: ADV_CD, DOC_DATE, DOC_NR, ERO_NR, ID_NR, NSNa, RCVD_DATE

APPLIICABLE MOEs: 2.1b, 2.2c

DESCRIPTION: A file which marries range of demanded consumable to specific weapon systems using ERO_NR as a key. Includes only documents with an advice code of 2_ .

5. ERO/DOC/REP FILE

DATA ELEMENTS: ADV_CD, DOC_DATE, DOC_NR, ERO_NR, ID_NR, NSNa, RCVD_DATE

APPLICABLE MOEs: 2.1c, 2.2e

DESCRIPTION: A file which marries the range of demanded reparables to specific weapon systems using ERO_NR as a key. Includes only documents with an advice code of F_.

6. ERO/DOC/SUM FILE

DATA ELEMENTS: DOC_DATE, DOC_NR, ERO_NR, ID_NR, NSNa, Qa, RCVD_DATE

APPLICABLE MOE: 2.2b

DESCRIPTION: A file which marries the depth of demanded repair parts to specific weapon systems using ERO_NR as a key.

7. <u>ERO/DOC/CON/SUM FILE</u>

DATA ELEMENTS: ADV_CD, DOC_DATE, DOC_NR, ERO_NR, ID_NR, NSNa, Qa, RCVD_DATE

APPLICABLE MOE: 2.2d

DESCRIPTION: A file which marries the depth of demanded consumables to specific weapon systems using ERO_NR as a key. Includes only document numbers with an advice code of 2_.

8. <u>ERO/DOC/REP/SUM FILE</u>

DATA ELEMENTS: ADV_CD, DOC_DATE, DOC_NR, ERO_NR, ID_NR, NSNa, Qa, RCVD_DATE

APPLICABLE MOEs: 2.2f

DESCRIPTION: A file which marries the depth of demanded reparables to specific weapon systems using the ERO_NR as a key. Includes only documents with an advice code of F_.

9. <u>ERO/DOC/CRIT FILE</u>

DATA ELEMENTS: DOC_DATE, DOC_NR, ERO_NR, ID_NR, NMCS, NSNa, Qa, RCVD_DATE

APPLICABLE MOEs: 2.1a, 2.4, 4.4

DESCRIPTION: A file which marries demand for critical parts to specific weapon systems using the ERO_NR as a key. Includes only documents with a NMCS indicator of N or 9.

10. <u>PROVISIONING FILE</u>

DATA ELEMENTS: ID_NR, NSNp, Qp, U/P

APPLICABLE MOEs: 1.1, 1.2, 2.1a, 2.1b, 2.1c, 2.2a, 2.2b, 2.2c, 2.2d, 2.2e, 2.2f, 2.3, 2.4, 3.1, 3.2, 3.3, 5.1, 5.2,

DESCRIPTION: A file initially derived from the Initial Issue Control File which consists of repair parts in the IIP.

11. <u>PROV/CRIT FILE</u>

DATA ELEMENTS: CEC, ID_NR, NSNp, Qp, U/P

APPLICABLE MOEs: 4.1, 4.2, 4.3, 4.4

DESCRIPTION: A file which contains only critical repair parts of IIP. A CEC of 4 or 5 denotes critical repair part.

APPENDIX D

MOE DEFINITION

In this appendix, the 23 proposed MOEs are defined and their data elements are identified. Also listed are the files necessary should a file processing procedure be required.

1. WEAPON SYSTEM AVAILABILITY (Ao)

MOE NUMBER: 1.1

DATA ELEMENTS: CAT_CD, DDL, DCD, DEF_CD, DOC_DATE, DOC_NR, EOTC, ERO_NR, ERO_CLOS, ID_NR, JOB_STAT, MIL_LAB_HRS NSNa, NSNp, RCVD_DATE, SER_NR

FILES REQUIRED: ERO History File
Document Status File
ERO/DOC File
Provisioning File

DESCRIPTION: A percentage measure of weapon system readiness. Will range from 0 to 100% with 100% indicating that all weapon systems were operable for the given time period.

2. <u>NON-AVAILABILITY PROVISIONING (Np)</u>

MOE NUMBER: 1.2

DATA ELEMENTS: CAT_CD, DDL, DCD, DEF_CD, DOC_DATE, DOC_NR, EOTC, ERO_NR, ERO_CLOS, ID_NR, JOB_STAT, MIL_LAB_HRS, NSNa, NSNp, SER_NR

FILES REQUIRED: ERO History File
Document Status File

ERO/DOC File
Provisioning File

DESCRIPTION: A percentage of the contribution of repair part shortages to a weapon system's deadline rate. Will range from 0 to 100% with 0% meaning no weapon system was deadlined for want of parts.

3. <u>TOTAL MSRT (MSRTt)</u>

MOE NUMBER: 2.1a

DATA ELEMENTS: DOC_DATE, DOC_NR, ERO_NR, ID_NR, NSNa, NSNp, RCVD_DATE

FILES REQUIRED: ERO/DOC File
Provisioning File

DESCRIPTION: The average number of days delay for all repair parts for a weapon system.

4. <u>CONSUMABLE MSRT (MSRTc)</u>

MOE NUMBER: 2.1b

DATA ELEMENTS: ADV_CD, DOC_DATE, DOC_NR, ERO_NR, ID_NR, NSNa, NSNp, RCVD_DATE

FILES REQUIRED: ERO/DOC/CON File
Provisioning File

DESCRIPTION: The average number of days delay for consumables.

5. <u>REPARABLE MSRT (MSRTr)</u>

MOE NUMBER: 2.1c

DATA ELEMENTS: ADV_CD, DOC_DATE, DOC_NR, ERO_NR, ID_NR, NSNa, NSNp, RCVD_DATE

FILES REQUIRED: ERO/DOC/REP File
Provisioning File

DESCRIPTION: The average number of days delay for reparables.

6. <u>TOTAL SMA RANGE (SMAt,r)</u>

MOE NUMBER: 2.2a

DATA ELEMENTS: DOC_NR, ERO_NR, ID_NR, NSNa, NSNp

FILES REQUIRED: ERO/DOC File
Provisioning File

DESCRIPTION: A percentage of the IIP range match to actual demand. A value of 100% shows that all range demands were met by the IIP.

7. <u>TOTAL SMA DEPTH (SMAt,d)</u>

MOE NUMBER: 2.2b

DATA ELEMENTS: DOC_NR, ERO_NR, ID_NR, NSNa, NSNp, Qa, Qp,

FILES REQUIRED: ERO/DOC/SUM File
Provisioning File

DESCRIPTION: A percentage of the IIP depth match to actual demand. A value of 100% shows all demands were met by the IIP.

8. <u>CONSUMABLE SMA RANGE (SMAc,r)</u>

MOE NUMBER: 2.2c

DATA ELEMENTS: ADV_CD, DOC_NR, ERO_NR, ID_NR, NSNa, NSNp

FILES REQUIRED: ERO/DOC/CON File
Provisioning File

DESCRIPTION: A percentage of the IIP range match to actual demand for consumable items.

9. <u>CONSUMABLE SMA DEPTH (SMAc,d)</u>

MOE NUMBER: 2.2d

DATA ELEMENTS: ADV_CD, DOC_NR, ERO_NR, ID_NR, NSNa, NSNp, Qa, Qp

FILES REQUIRED: ERO/DOC/CON/SUM File
Provisioning File

DESCRIPTION: A percentage of the IIP depth match to actual demand for consumables.

10. <u>REPARABLE SMA RANGE (SMAr,r)</u>

MOE NUMBER: 2.2e

DATA ELEMENTS: ADV_CD, DOC_NR, ERO_NR, ID_NR, NSNa, NSNp

FILES REQUIRED: ERO/DOC/REP File
Provisioning File

DESCRIPTION: A percentage of the IIP range match to actual demand for reparables.

11. <u>REPARABLE SMA DEPTH (SMAr,d)</u>

MOE NUMBER: 2.2f

DATA ELEMENTS: ADV_CD, DOC_NR, ERO_NR, ID_NR, NSNa, NSNp, Qa, Qp

FILES REQUIRED: ERO/DOC/REP/SUM File
Provisioning File

DESCRIPTION: A percentage of the IIP depth match to actual demand for reparables.

12. BACKORDER PERCENTAGE

MOE NUMBER: 2.3

DATA ELEMENTS: DOC_NR, ERO_NR, ID_NR, NSNa, NSNp,

FILES REQUIRED: ERO/DOC File
Provisioning File

DESCRIPTION: A percentage of the actual demand depth that was not met by the IIP. Simply one minus SMAt,d.

13. AVERAGE DAYS DELAY FOR DELAYED REQUISITIONS (ADDDR)

MOE NUMBER: 2.4

DATA ELEMENTS: DOC_DATE, DOC_NR, ERO_NR, ID_NR, NSNa, NSNp

FILES REQUIRED: ERO/DOC File
Provisioning File

DESCRIPTION: The average days delay for critical parts that were backordered. Simply the MSRTt divided by one minus the SMAt,d.

14. INVESTMENT COST

MOE NUMBER: 3.1

DATA ELEMENTS: ID_NR, Qp, U/P

FILES REQUIRED: Provisioning File

DESCRIPTION: The dollar value of initial investment in the IIP.

15. ORDER COST

MOE NUMBER: 3.2

DATA ELEMENTS: DOC_NR, ERO_NR, ID_NR, K1, NSNa, NSNp, Qa, Qp, U/P

FILES REQUIRED: ERO/DOC File
Provisioning File

DESCRIPTION: A dollar estimate of expedited processing for demanded parts that were not in the IIP.

16. TOTAL OVERAGE COST

MOE NUMBER: 3.3

DATA ELEMENTS: DOC_NR, ERO_NR, ID_NR, K2, NSNa, NSNp, Qa,Qp, U/P

FILES REQUIRED: ERO/DOC File
Provisioning File

DESCRIPTION: A dollar estimate of the inventory holding costs, cosolescence costs and the time value of money of IIP repair parts that were not demanded.

17. OVERAGE PERCENTAGE

MOE NUMBER: 3.4

DATA ELEMENTS: DOC_NR, ERO_NR, ID_NR, NSNa, NSNp, Qa, Qp, U/P

FILES REQUIRED: ERO/DOC File
Provisioning File

DESCRIPTION: A percentage of the dollar value of excesses to the IIP investment cost.

18. PERCENTAGE IIP CRITICAL, RANGE

MOE NUMBER: 4.1

DATA ELEMENTS: CEC, ID_NR, NSNp

FILE REQUIRED: PROV/CRIT File

DESCRIPTION: A percentage of critical parts range to total IIP range.

19. PERCENTAGE IIP CRITICAL, DEPTH

MOE NUMBER: 4.2

DATA ELEMENTS: CEC, ID_NR, NSNp, Qp

FILE REQUIRED: PROV/CRIT File

DESCRIPTION: A percentage of the critical parts depth to total IIP depth.

20. PERCENTAGE IIP CRITICAL, DOLLAR VALUE

MOE NUMBER: 4.3

DATA ELEMENTS: CEC, ID_NR, NSNp, Qp, U/P

FILE REQUIRED: PROV/CRIT File

DESCRIPTION: A percentage of the critical part dollar value to the total IIP dollar value.

21. PERCENTAGE IIP CRITICAL, SHORTAGES

MOE NUMBER: 4.4

DATA ELEMENTS: CEC, DOC_NR, ERO_NR, ID_NR, NMCS, NSNa, NSNp, Qa, Qp

FILES REQUIRED: ERO/DOC/CRIT File
PROV/CRIT File

DESCRIPTION: A percentage of critical part shortages to total number of IIP shortages.

22. PERCENTAGE NO-DEMAND, RANGE

MOE NUMBER: 5.1

DATA ELEMENTS: DOC_NR, ERO_NR, ID_NR, NSNa, NSNp

FILES REQUIRED: ERO/DOC File
Provisioning File

DESCRIPTION: A percentage of no-demand, range for IIP parts.

23. PERCENTAGE NO-DEMAND, DEPTH

MOE NUMBER: 5.2

DATA ELEMENTS: DOC_NR, ERO_NR, ID_NR, NSNa, NSNp, Qa, Qp

FILES REQUIRED: ERO/DOC File
Provisioning File

DESCRIPTION: A percentage of no-demand, depth for IIP parts.

APPENDIX F

MOE/DATA ELEMENT MATRIX

Refer to Appendix B for data element abbreviations and Appendix D for MOE numbering.

MOE NUMBERS

DATA ELEMENT	1.1	1.2	2.1a	2.1b	2.1e	2.2a	2.2b	2.2c
ADV_CD				*	*			*
CAT_CD	*	*						
CEC								
DDL	*	*						
DCD	*	*						
DEF_CD	*	*						
DOC_DATE	*	*	*	*	*			
DOC_NR	*	*	*	*	*	*	*	*
EOTC	*	*						
ERO_NR	*	*	*	*	*	*	*	*
ERO_CLOS	*	*						
ID_NR	*	*	*	*	*	*	*	*
JOB_STAT	*	*						
K1								
K2								
MIL_LAB_HRS	*	*						
NSNa	*	*	*	*	*	*	*	*
NSNp	*	*	*	*	*	*	*	*
NMCS								
Qa							*	
Qp							*	
RCVD_DATE	*	*	*	*	*			
SER_NR	*	*						
U/P								

MOE NUMBERS

DATA ELEMENT	2.2d	2.2e	2.2f	2.3	2.4	3.1	3.2	3.3
ADV_CD	*	*	*					
CAT_CD								
CEC								
DDL								
DCD								
DEF_CD								
DOC_DATE					*			
DOC_NR	*	*	*	*	*		*	*
EOTC								
ERO_NR	*	*	*	*	*		*	*
ERO_CLOS								
ID_NR	*	*	*	*	*	*	*	*
JOB_STST								
K1							*	
K2								*
MIL_LAB_HRS								
NSNa	*	*	*	*	*		*	*
NSNp	*	*	*	*	*		*	*
NMCS								
Qa	*		*				*	*
Qp	*		*			*	*	*
RCVD_DATE								
SER_NR								
U/P						*	*	*

MOE NUMBERS

DATA ELEMENT	3.4	4.1	4.2	4.3	4.4	5.1	5.2
ADV_CD							
CAT_CD							
CEC		*	*	*	*		
DDL							
DCD							
DEF_CD							
DOC_DATE							
DOC_NR	*				*	*	*
EOTC							
ERO_NR	*				*	*	*
ERO_CLOS							
ID_NR	*	*	*	*	*	*	*
JOB_STAT							
K1							
K2							
MIL_LAB_HRS							
NSNa	*				*	*	*
NSNp	*	*	*	*	*	*	*
NMCS					*		
Qa	*				*		*
Qp	*		*	*	*		*
RCVD_DATE							
SEP_NR							
U/P	*			*			

LIST OF REFERENCES

1. Kelley, P.X., "Statement on Posture, Plans and Programs for Fiscal Years 1987 through 1991", Address to Congress, Marine Corps Gazette, April 1986.

2. Marine Corps Logistics Base, Albany, Georgia, Weapon Systems/Management Directorate (Provisioning), Marine Corps Stock Fund--Procurement, Marine Corps Financial Plan and Consolidated Summary, Fiscal Years 1987 to 1993.

3. United States Marine Corps, Provisioning Manual, MCO P4400.79E, 31 January 1986.

4. Lee, Paul Melvin, Provisioning Responsibilities, Procedures, and Requirements Determination in the United States Marine Corps, M.S. Thesis, Naval Postgraduate School, Monterey, California, September 1979.

5. United States Marine Corps, Marine Corps Provisioning Policy Review Staff Study Report, Headquarters Marine Corps, 23 October 1980.

6. Department of Defense, Basic Objectives and Policies on Provisioning of End Items of Material, DODD 4140.40, February 20, 1973.

7. Department of Defense, Determination of Initial Requirements for Secondary Item Spares and Repair Parts, DODI 4140.42, 7 August 1974.

8. United States Marine Corps, Marine Corps Unified Material Management System (MUMMS) Inventory Control Manual, MCO 4400.72C, 20 March 1980.

9. Department of Defense MIL-STD-1388-1A, Logistic Support Analysis, 11 April 1983.

10. Department of Defense MIL-STD-1388-2A, DOD Requirements for a Logistic Support Analysis Record, 20 July 1984.

11. United States Marine Corps, U.S. Marine Corps Level of Repair (LOR) Analysis Program, User's Manual, June 1985.

12. Love, R.E., and Stebbins, B.F., An Analysis of Spare Parts Forecasting Methods Utilized in the United States Marine Corps, M.S. Thesis, Naval Postgraduate School, Monterey, California, September 1986.

13. Johnson, W.F., Major, USMC, Weapon Systems Management Directorate, MCLBA, telephone interview with the researcher, 26 August 1987.

14. United States Marine Corps, 1985 Provisioning Effectiveness Study Candidates, Headquarters MarineCorps, 30 April 1985.

15. United States Marine Corps, Changes to Marine Corps Integrated Maintenance Management System (MIMMS) Field Reporting Procedures to Support Logistics Programs, CMC letter 4790/LMM-3/1503, 24 July 1985.

16. Department of Defense, Secondary Item Weapon System Management Concept and Implementation Plans, April 1986.

17. Marine Corps Logistic Base, Albany, Georgia, Secondary Item Weapon System Management, DODIG (Project 7SS-009) Visit, MCLB Deputy Commander Memorandum, 6 March 1987.

18. Rosconi, Robert J., Systems Engineering, Weapon System Automated Information Systems, Command Brief, Weapon Systems Management Directorate, MCLBA, March 1987.

19. Blanchard, B.S., Logistics Engineering and Management, 3rd Edition, Prentice-Hall Inc., Englewood Cliffs, N.J., 1986.

20. Department of Defense, Report of the Defense Science Board 1981 Summer Study Panel on OPERATIONAL READINESS WITH HIGH PERFORMANCE SYSTEMS, Office of the Under Secretary of Defense for Research and Engineering, April 1982.

21. United States Navy, Operational Availability of Weapon Systems and Equipments; definition and policy, NAVMATINST 3000.2, 21 January 1981.

22. Naval Postgraduate School Technical Report NPS 55-83-026, Wholesale Provisioning Models: Model Development, by A.W. McMasters and F.R. Richards, September 1983.

23. United States Navy, Inventory Management, NAVSUP Publication 553, 1984.

24. General Accounting Office Report to the Secretary of Defense, PLRD-82-25, Mission Item Essentiality: An Important Management Tool for Making More Informed Logistics Decisions, January 13, 1982.

25. Logistics Management Institute Report, Nondemand-Based Stockage Policies, by K.K. Kiebler and A.J. Colaianni, June 1986.

26. United States Marine Corps, MIMMS User's Manual, UM-4790-5, 2 January 1987.

27. United States Marine Corps, Table of Marine Corps Automated Readiness Evaluation System (MARES) Logistics Reportable Items for the Status of Resources and Training System, McBul 3000, 8 September 1987.

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